Introduction to Electronics (Practice paper - 5)

Topic: MOSFET and Amplifiers

1. For the n-channel MOSFET as shown in Fig. 1 has $K_n = 0.2$ mA/V^2 and $V_{Th} = 1$ V. Given that $V_{DD} = 10$ V and $R_D = 1$ kΩ. Find (a) the region operation, (b) V_{GS} (c) V_{DS} and (d) i_D.

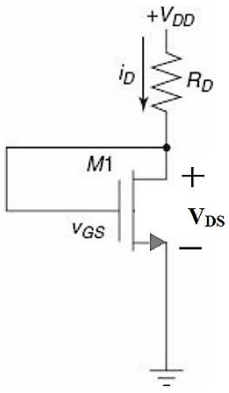

Fig. 1

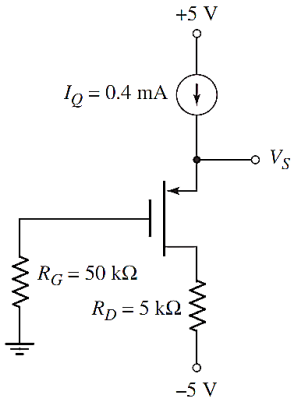

Fig. 2

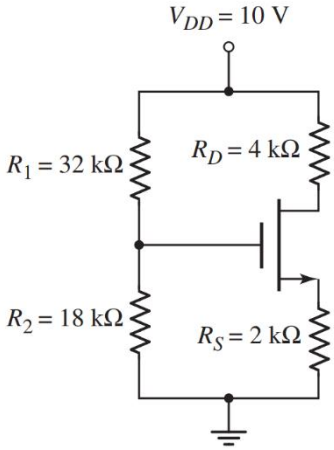

Fig. 3

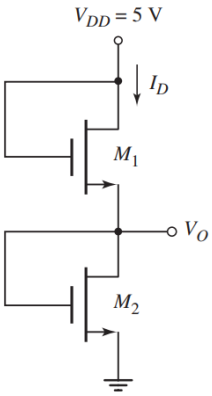

Fig. 4

2. For the circuit in Figure 2, the p-channel transistor has threshold voltage (V_{Th}) = −0.8 V and $K_p = 200$ μA/V^2. Determine V_S and V_{SD}.

3. A particular n-channel MOSFET has parameters $V_{Th} = 0.6$ V, L = 0.8 μm, $t_{ox} = 200$ Å, and $\mu_n = 600$ cm^2/V–s. A drain current of $I_D = 1.2$ mA is required when the device is biased in the saturation region at $V_{GS} = 3$ V. Determine the required channel width of the device.

4. For a p-channel enhancement-mode MOSFET, the parameters are $K_P = 2$ mA/V^2 and $V_{TP} = -0.5$ V. The gate is at ground potential, and the source terminals is at +5 V. Determine I_D when the drain terminal voltage is: (a) $V_D = 0$ V, (b) $V_D = 2$ V, (c) $V_D = 4$ V, and (d) $V_D = 5$ V.

5. In the circuit shown in Fig. 3, the transistor parameters are $V_{Th} = 0.8$ V and $K_n = 0.5$ mA/V^2. Calculate (i) Drain current I_D, (ii) Gate-source voltage (V_{GS}), and (iii) Drain-source voltage (V_{DS}).

6. The transistors (M_1 & M_2) in the circuit shown in Fig. 4 have parameters $V_{Th} = 0.4$ V and $K_n' = 120$ μA/V^2. (a) If the width-to-length ratios of M_1 and M_2 are $(W/L)_1 = (W/L)_2 = 30$, determine V_{GS1}, V_{GS2}, V_O, and I_D. (b) Repeat part (a) if the width-to-length ratios are changed to $(W/L)_1 = 30$ and $(W/L)_2 = 15$.

7. In the circuit shown in Fig. 5, find the value of R_S and R_D when V_D = -3 V and $I_D = 0.5$ mA. The transistor parameters are given as K_p' = 30 μA/V^2, W/L = 20 and V_{Th} = -1.2 V.

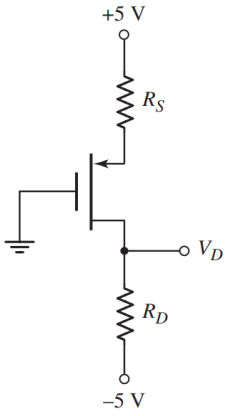

Fig. 5

8. The circuit shown in Fig. 6 have transistor parameters $V_{Th} = -1.75$ V and $K_p = 3$ mA/V^2. The drain current (I_D) in the circuit is 5 mA, $V_{SD} = 6$ V and $R_{in} = 80$ kΩ. Find R_1, R_2 and R_D.

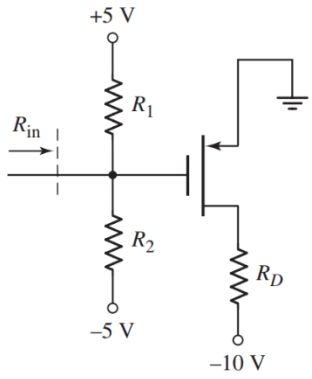

Fig. 6

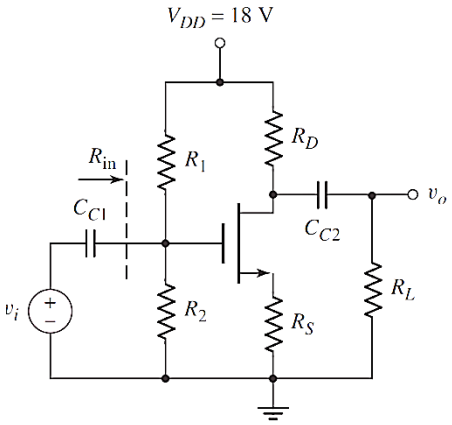

Fig. 7

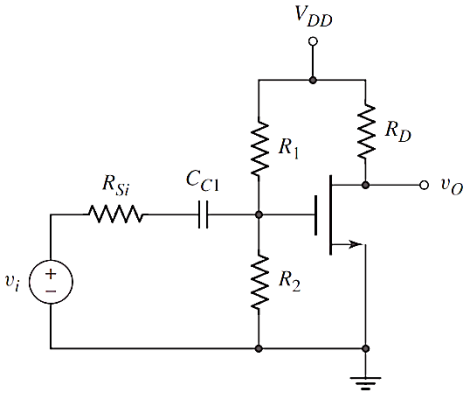

Fig. 8

9. In the common-source amplifier circuit shown in Fig. 7 using an n-channel MOSFET quiescent values are $I_{DQ} = 6$ mA, $V_{GSQ} = 2.8$ V, and $V_{DSQ} = 10$ V. The transconductance is $g_m = 2.2$ mA/V. Consider, $\lambda = 0$, $R_L = 1$ kΩ, $A_v = -1$, and $R_{in} = 100$ kΩ. Find R_1, R_2, R_S, R_D, K_n, and V_{Th}.

10. The parameters of the circuit shown in Fig. 8 are $V_{DD} = 5$ V, $R_1 = 520$ kΩ, $R_2 = 320$ kΩ, $R_D = 10$ kΩ, and $R_{Si} = 0$. Assume transistor parameters of $V_{Th} = 0.8$ V, $K_n = 0.20$ mA/V^2, and $\lambda = 0$. (a) Determine the small-signal transistor parameters g_m and r_o. (b) Find the small-signal voltage gain. (c) Calculate the input and output resistances. (d) Repeat (a) and (b) considering $R_{Si} = 1$ kΩ.

11. Consider the NMOS amplifier with saturated load in Fig. 9. The transistor parameters are $V_{Th\_D} = V_{Th\_N} = 0.6$ V, $k_n' = 100$ μA/V^2, $\lambda = 0$, and $(W/L)_L = 1$. Estimate the W/L ratio of M_D for realizing the overall small-signal voltage gain |Av| = 5.

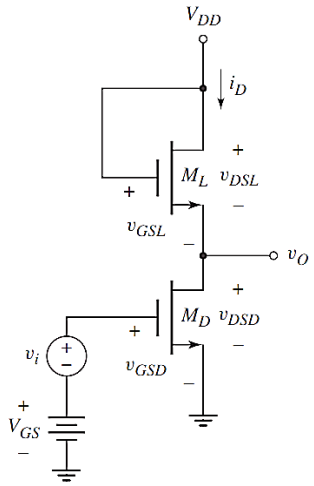

Fig. 9

Please Note: For n-channel MOSFET

$K_n = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}$ is the conduction parameter

$K_n = \frac{1}{2}K_n'\frac{W}{L}$

$K_n' = \mu_n C_{ox}$ is the process conduction parameter